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On Achievable Rate Regions for the Gaussian Interference Channel

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Abstract

The complete characterization of the capacity region of a two-user Gaussian interference channel is still an open problem unless the interference is strong. In this work, we derive an achievable rate region for this channel. It includes the rate region which is achieved by time/ frequency division multiplexing (TDM/ FDM), and it also includes the rate region which is obtained by time-sharing between the two rate pairs where one of the transmitters sends its data reliably at the maximal possible rate (i.e., the maximum rate it can achieve in the absence of interference), and the other transmitter decreases its data rate to the point where both receivers can reliably decode its message. The suggested rate region is easily calculable, though it is a particular case of the celebrated achievable rate region of Han and Kobayashi whose calculation is in general prohibitively complex. In the high power regime, a lower bound on the sum-capacity (i.e., the maximal achievable total rate) is derived, and we show its superiority over the maximal total rate which is achieved by the TDM/ FDM approach with moderate interference. For degraded and one-sided Gaussian interference channels, we rely on some observations of Costa and Sato, and obtain directly their sum-capacities. We conclude our discussion by pointing out two interesting open problems.

1 Model and Definition of Capacity Region

An interference channel (IC) models the situation where a number (M) of unrelated senders try to communicate their separate information to M different receivers via a common channel. Transmission of information from each sender to its corresponding receiver interferes with the communication between the other senders and their receivers.
A two-user (i.e, $M = 2$) discrete, memoryless IC consists of four finite sets $\mathcal{X}_1, \mathcal{X}_2, \mathcal{Y}_1, \mathcal{Y}_2$, and conditional probability distributions $p(\cdot, \cdot|x_1, x_2)$ on $\mathcal{Y}_1 \times \mathcal{Y}_2$, where $(x_1, x_2) \in \mathcal{X}_1 \times \mathcal{X}_2$. For coded information of block length n, the two-user discrete, memoryless IC is denoted by

$$(\mathcal{X}_1^n \times \mathcal{X}_2^n, p^n(\mathbf{y}_1, \mathbf{y}_2|\mathbf{x}_1, \mathbf{x}_2), \mathcal{Y}_1^n \times \mathcal{Y}_2^n)\,,$$

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